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GOOD AFTERNOON LADIES AND GENTLEMEN. IT IS GOOD TO HAVE THIS OPPORTUNITY TO TALK WITH CONSTRUCTIVELY ACTIVE FELLOW ENGINEERS ABOUT A SUBJECT OF GREAT ENGINEERING INTEREST AND OF VITAL IMPORTANCE TO THE FUTURE OF OUR COUNTRY,--THE CIVIL SPACE PROGRAM OF THE UNITED STATES.

AS YOU ALL KNOW, WE HAVE JUST EXPERIENCED THE TRIUMPHANT RETURN OF THE SPACE SHUTTLE TO ACTION WITH THE FLAWLESS FLIGHT OF THE ORBITER DISCOVERY, A SPACE VOYAGE THAT HAS PROVED OUT BEFORE THE WATCHING WORLD THE EFFECTIVENESS OF THE REDESIGNED AND GREATLY IMPROVED SPACE TRANSPORTATION SYSTEM.

OUR COUNTRY IS ON THE MOVE AGAIN IN SPACE, AND THE FUTURE IS FULL OF CHALLENGE AND EXCITEMENT AS WE NOW BEGIN TO WORK OFF A TREMENDOUS BACKLOG OF MAJOR SCIENCE PAYLOADS, AND FORGE AHEAD WITH THE LOGICAL AND INDISPENSABLE NEXT STEP, THE CONSTRUCTION, ASSEMBLY AND MANNING OF THE FREEDOM SPACE STATION.

I WOULD LIKE TO USE THE TIME YOU HAVE GIVEN ME TODAY TO TELL YOU SOMETHING ABOUT SOME OF THE IMPORTANT MISSIONS WE WILL BE FLYING IN THE NEXT FEW YEARS, AND ABOUT THE SPACE STATION ITSELF, ITS FUNCTIONS, AND IN PARTICULAR THE ENGINEERING CHALLENGES IT POSES.

LET'S START WITH A FEW OF THE SCIENCE PAYLOADS COMING UP.

PERHAPS THE MOST EXCITING OF ALL IS THE HUBBLE SPACE TELESCOPE SCHEDULED FOR A SHUTTLE LAUNCH LATE NEXT SUMMER. THE HUBBLE IS THE MOST POWERFUL TELESCOPE EVER BUILT, AND SOME SAY THE MOST IMPORTANT INSTRUMENT EVER PLACED IN SPACE. ASTROMOMERS HAVE EVEN EQUATED ITS SIGNIFICANCE TO GALILEO'S ORIGINAL INSTRUMENT. FROM ORBIT ABOVE THE OBSCURING ATMOSPHERE, IT WILL BE ABLE TO DISTINGUISH OBJECTS FIFTY TIMES DIMMER THAN THE DIMMEST WE CAN SEE TODAY WITH THE BEST TELECOPES ON EARTH, AND LOOK OUT IN DISTANCE AND BACK IN TIME NEARLY TO THE LIMITS OF THE UNIVERSE AND ALMOST TO THE PRIMAL "BIG BANG" ITSELF. WITH THIS MAGNIFICENT INSTRUMENT WE MAY BE ABLE TO OBSERVE DIRECTLY FOR THE FIRST TIME PLANETARY SYSTEMS LIKE OUR OWN IN ORBIT AROUND OTHER STARS.

IT IS EVEN POSSIBLE THAT ASTRONOMERS CAN LEARN ENOUGH ABOUT THE MACRO-PROCESSES OF THE UNIVERSE TO RELATE THEM TO THE PARTICULAR PHYSICS OF THE ATOM, AND THUS FINALLY VALIDATE THE ELUSIVE THEORY OF THE UNIFIED FIELD.

COMPLEMENTING THE OBSERVATIONS OF THE HUBBLE TELESCOPE WILL BE THE MAGELLAN HIGH RESOLUTION MAPPING MISSION TO VENUS, SCHEDULED FOR LAUNCH IN MID-1989. LIKE ITS NAMESAKE, THIS SPACECRAFT WILL BE A CIRCUMNAVIGATOR, AND IT WILL CIRCUMNAVIGATE OUR SISTER PLANET NOT ONCE BUT MANY TIMES, LOOKING DOWN THROUGH THE SULFUREOUS CLOUD COVER WITH A SYNTHETIC APERTURE RADAR FOR EIGHT MONTHS. WE EXPECT THAT WHAT WE WILL GET WILL BE A MAP OF THE INVISIBLE BUT DRAMATIC VENUSIAN TOPOGRAPHY WITH AN OVERALL RESOLUTION OF ONLY ONE KILOMETER, AND WITH A MAXIMUM OF ONLY 125 METERS IN SELECTED AREAS.

A SECOND PLANETARY MISSION NEXT YEAR WILL ALSO BE GOING TO VENUS, BUT NOT TO STAY. GALILEO'S ULTIMATE DESTINATION WILL BE JUPITER WHOSE MOONS WERE DISCOVERED BY ITS NAMESAKE BACK IN 1610. BUT IT WILL GO THERE VIA VENUS AND EARTH TO GAIN THE NECESSARY VELOCITY FOR ITS SIX-YEAR MISSION. ONCE AT JUPITER, IT WILL SEND DOWN A PROBE TO MAKE THE FIRST MEASUREMENTS DEEP IN THE JOVIAN ATMOSPHERE, AND THEN CONDUCT AT LEAST TEN ORBITS OF THE GIANT PLANET INVOLVING SIXTEEN ENCOUNTERS WITH ITS MOONS.

IN 1990 WE WILL BE LAUNCHING THE ULYSSES SPACECRAFT TO THE SUN. IT WILL GO FIRST TO JUPITER AND USE THAT PLANET'S POWERFUL GRAVITY TO SLING IT OUT OF THE PLANE OF THE ECLIPTIC AND UP OVER THE UNSEEN AND UNKNOWN POLES OF OUR LOCAL STAR ON WHICH ALL THE LIFE WE KNOW DEPENDS.

EARLY THAT SAME YEAR, WE EXPECT TO LAUNCH ANOTHER IMPORTANT INSTRUMENT, THE GAMMA RAY OBSERVATORY, TO INVESTIGATE THIS MOST ENERGETIC OF ALL FORMS OF ELECTROMAGNETIC RADIATION AND ITS EQUALLY VIOLENT SOURCES--PULSARS, QUASARS, BLACK HOLES, AND OTHER OBJECTS THAT HAVE NOT BEEN IDENTIFIED AT ANY OTHER WAVELENGTH. AFTER THE HUBBLE TELESCOPE, THE GRO IS THE SECOND OF WHAT WE CALL THE FOUR GREAT OBSERVATORIES. AND LIKE THE TELESCOPE, IT WILL BE TENDED AND UPDATED BY ASTRONAUTS FROM THE SHUTTLE AND THE SPACE STATION.

TWO YEARS LATER AN OBSERVER WILL FOLLOW THE MARINERS AND THE HUGELY SUCCESSFUL AND LONG-LIVED VIKINGS TO MARS. THERE IT WILL STUDY THE GEOLOGY AND CLIMATOLOGY OF THE RED PLANET FROM A SUN-SYNCHRONOUS, LOW ALTITUDE POLAR ORBIT, CONDUCT A THOROUGH MAPPING, AND LOOK ESPECIALLY FOR ANY CLUES TO THE EXISTENCE OF SURFACE WATER IN THE PAST. MISSION DURATION IS PLANNED FOR TWENTY-TWO MONTHS, OR ONE MARTIAN YEAR, IN ORDER TO OBSERVE DURING ALL FOUR SEASONS.

THEN, IN THE MIDDLE NINETIES, WE PLAN THE LAUNCH OF THE LAST TWO OF THE GREAT OBSERVATORIES--THE ADVANCED X-RAY ASTROPHISICS FACILITY OR AXAF, AND THE SPACE INFRARED TELESCOPE FACILITY, OR SIRTF.

AXAF WILL MEASURE AND EVALUATE THE X-RAY EMISSIONS FROM SUPERNOVA REMNANTS, BLACK HOLES, PULSARS, QUASARS AND IN FACT NEARLY EVERY KNOWN OBJECT IN THE UNIVERSE, PROBING FOR ANSWERS TO SOME OF THE FUNDAMENTAL QUESTIONS IN PHYSICS AND ASTRONOMY.

SIRTF WILL BE EXAMINING THE INFRARED RADIATION FROM STAR FORMATION, INFRARED GALAXIES, SOLAR SYSTEM BODIES, AND AGAIN, FROM JUST ABOUT EVERY KNOWN OBJECT OUT THERE.

IN THE SAME TIME FRAME, AND POTENTIALLY OF HUGE SIGNIFICANCE, A SO-CALLED "MISSION TO PLANET EARTH" WILL MAKE USE OF A POLAR PLATFORM ASSOCIATED WITH THE FREEDOM STATION, AND FURNISHED BY THE EUROPEAN SPACE AGENCY, TO INVESTIGATE ON A GLOBAL SCALE, HOW THE HIGHLY INTERACTIVE SYSTEM COMPOSED OF THE NOT-SO-SOLID EARTH, THE OCEANS, THE ATMOSPHERE AND BIOSPHERE, HAS EVOLVED, HOW IT FUNCTIONS, AND HOW IT HAS BEEN, IS BEING AND COULD BE AFFECTED BY HUMAN ACTIVITIES.

SINCE, AS STRONGLY INDICATED BY THE NEARLY UNPRECEDENTED HEAT AND DROUGHT OF LAST SUMMER, THERE SEEMS TO BE A VERY REAL POSSIBILITY THAT WHAT WE DO HERE ON ITS SURFACE COULD PERMANENTLY ALTER THE HABITABILITY OF OUR PLANET, THIS MIGHT WELL BE THE MOST IMPORTANT SPACE MISSION OF ALL.

THE RECENTLY ESTABLISHED COMMITTEE ON EARTH SCIENCES, ON WHICH IT IS MY PRIVELEGE TO REPRESENT NASA, WILL BE DEEPLY INVOLVED IN THAT EFFORT.

AND AS A NATIONAL LABORATORY, THE STATION'S FACILITIES WILL BE AVAILABLE TO ASSIST IN THE DEVELOPMENT OF COMMERCIAL SPACE VENTURES AS WELL. INDEED THE STATION IS CRUCICAL TO INDUSTRY'S FUTURE IN SPACE, AND IT IS OUR POLICY TO ENCOURAGE THE PRIVATE SECTOR TO PARTICIPATE IN BOTH THE DEVELOPMENT AND THE USE OF THE STATION.

BUT THE STATION WILL BE MORE THAN A NATIONAL LABORATORY. IT WILL BE, IN THE MOST LITERAL SENSE, A STEPPING STONE TO FUTURE MANNED AND UNMANNED EXPLORATIONS OF THE SOLAR SYSTEM AND BEYOND.

I BELIEVE THAT, SOONER OR LATER, THE HUMAN IMPERATIVE OF EXPLORATION, THE BASIC NEED TO KNOW INHERENT IN MANKIND, WILL CAUSE US ONCE AGAIN TO BREAK THE BONDS OF EARTH. WHETHER WE WILL CHOOSE TO FOLLOW THE TRAIL OF THE APOLLO ASTRONAUTS AND ESTABLISH A BASE ON THE MOON, OR BOLDLY STRIKE OUT FOR MARS, HUMAN BEINGS WILL NOT REMAIN EARTHBOUND MUCH LONGER. WHEN THAT BREAKOUT WILL OCCUR, I HAVE NO WAY OF KNOWING. THAT IT WILL OCCUR, I HAVE NO DOUBT. AND WHEN IT DOES, THE STATION WILL BE THE ESSENTIAL STEPPING STONE TO SPACE FROM WHICH THOSE JOURNEYS WILL BEGIN.

YOU MAY HAVE NOTICED THAT IN THE COURSE OF MY REMARKS THUS FAR, I HAVE REPEATEDLY USED PHRASES SUCH AS "IN ASSOCIATION WITH THE SPACE STATION", AND " TENDED AND UPDATED BY ASTRONAUTS FROM THE SPACE STATION". AND IF FROM THOSE PHRASES YOU HAVE INFERRED THAT THE STATION IS CRITICAL TO ALMOST EVERYTHING WE WILL BE DOING IN SPACE FOR AT LEAST THE NEXT COUPLE OF DECADES, THAT INFERENCE IS, IN THE LANGUAGE OF OUR TIMES, RIGHT ON.

THE FREEDOM SPACE STATION, SCHEDULED FOR FIRST OPERATIONAL USE IN LOW EARTH ORBIT IN THE MIDDLE NINETIES, IS NOTHING SHORT OF THE KEY TO THE FUTURE OF THE CIVIL SPACE PROGRAM OF THE UNITED STATES. IT WILL OPEN A WHOLE NEW ERA OF EXPANDED DISCOVERY, OPPORTUNITY AND ACCOMPLISHMENT IN SPACE. WITH THE STATION, AMERICANS AND THEIR EUROPEAN, CANADIAN, AND JAPANESE PARTNERS, WILL NO LONGER BE OCCASIONAL VISITORS, BUT PERMANENT RESIDENTS IN SPACE.

ESSENTIALLY THE STATION WILL SERVE AS A NEW NATIONAL LABORATORY, SUSTAINING ADVANCED RESEARCH IN THE PHYSICAL, CHEMICAL AND BIOLOGICAL SCIENCES, INCLUDING SPECIFICALLY LIFE AND MATERIALS SCIENCES, FUNDAMENTAL RESEARCH IN CHEMISTRY AND PHYSICS AND SELECTED ASTROPHYSICS, EARTH SCIENCES AND SOLAR SYSTEM RESEARCH. AT THE SAME TIME IT WILL PROVIDE CONTINUOUS SCIENTIFIC ACCESS TO SPACE, AND RAPID RESPONSE RESEARCH OPPORTUNITIES.

BEFORE I GO ON TO DESCRIBE THE STATION AND THE ENGINEERING CHALLENGES INVOLVED, LET ME MAKE ONE MORE IMPORTANT PHILOSHPHICAL POINT. THE USE OF THE ADJECTIVE "NATIONAL", AS IN NATIONAL LABORATORY, IS DELIBERATE AND IMPORTANT.

THE SPACE STATION IS AN ENDEAVOR OF NATIONAL CONSEQUENCE TO WHICH THE GOVERNMENT AND THE PEOPLE OF THE UNITED STATES MUST BE, AND I BELIEVE ARE, COMMITTED IN A SUSTAINED AND CONSISTENT WAY. WE AT NASA, WITH OUR INTERNATIONAL PARTNERS, ARE DEVELOPING THIS VITAL PROJECT. BUT IT IS IMPORTANT TO REMEMBER THAT WE ARE DOING SO AS THE AGENT OF THE ENTIRE NATION.

WHAT WILL IT LOOK LIKE? IT WILL BE BIG, THE LARGEST STRUCTURE EVER PLACED IN SPACE. ITS MAIN FEATURE WILL BE A HORIZONTAL BOOM 508 FEET LONG, ASSEMBLED BY CONSTRUCTION TECHNIQUES PROVEN OUT BY TWO SUCCESSIVE EARLIER SHUTTLE FLIGHTS, IN TRUSS SEGMENTS COMPOSED PRIMARILY OF STRONG, LIGHT, GRAPHITE MATERIALS.

AT EACH END OF THE BOOM WILL BE TWO 208-FOOT HIGH VOLTAIC SOLAR PANELS THAT WILL GENERATE 75 KILOWATTS OF ELECTRICAL POWER, MORE THAN THE ACCUMULATED POWER ON ALL PREVIOUS U.S. SPACE PROJECTS. FOR PERSPECTIVE, THE SHUTTLE ORBITERS HAVE 12 KILOWATTS AND THE SOVIET MIR STATION ABOUT FIFTEEN.

AT THE CENTER OF THE BOOM WILL BE A CLUSTER OF FOUR PRESSURIZED MODULES. THREE OF THE MODULES, SUPPLIED RESPECTIVELY BY THE UNITED STATES, EUROPE AND JAPAN, WILL CONTAIN SCIENTIFIC INSTRUMENTS AND FACILITIES. THE FOURTH, ALSO SUPPLIED BY THE UNITED STATES, WILL HOUSE THE CREW OF UP TO EIGHT ASTRONAUTS. ALSO BASED NEAR THE CENTER OF THE BOOM WILL BE A NASA-DEVELOPED TELEROBOTIC SERVICER, AND A CANADA-SUPPLIED SOPHISTICATED ROBOT ARM, AN ADVANCED VERSION OF THE ONE NOW USED IN THE SHUTTLE ORBITERS. BOTH THESE DEVICES WILL ALSO BE USED IN THE CONSTRUCTION OF THE STATION.

NOT PHYSICALLY IN COMPANY, BUT PART OF THE BASELINE CONFIGURATION OF THE STATION, WILL BE TWO FREE-FLYING, UNMANNED PLATFORMS IN POLAR ORBIT, ONE DEVELOPED BY NASA AND ONE BY THE EUROPEAN SPACE AGENCY, TO COMPLEMENT THE FACILITIES AND FUNCTIONS OF THE STATION.

ALL OF THESE ELEMENTS WILL BE LIFTED INTO ORBIT BY THE SHUTTLE IN A SERIES OF FLIGHTS BEGINNING IN 1994. THE FIRST SIX PAYLOADS WILL TOTAL ALMOST 100 TONS THAT WHEN ASSEMBLED WILL COMPOSE A STATION, INCLUDING THE U.S. LABORATORY MODULE THAT CAN BE TENDED BY SHUTTLE-BORNE ASTRONAUTS.

IT WILL TAKE FOUR MORE SHUTTLE FLIGHTS, DELIVERING ANOTHER FIFTY TONS, INCLUDING THE HABITATION MODULE, TO PROVIDE PERMANENTLY MANNED CAPABILITY.

ANOTHER NINE FLIGHTS WILL COMPLETE THE JOB, AND THE CURRENTLY APPROVED "PHASE I" STATION WILL BE IN PLACE.

BUT THE DELIVERY OF THIS MORE THAN 250 TONS OF HARDWARE TO LOW EARTH ORBIT, AS DEMANDING AS IT WILL BE, IS THE EASY PART. THE MAJOR CHALLENGES WILL COME WITH THE ASSEMBLY OF

THESE COMPONENTS INTO AN OPERATIONAL ENTITY.

ALL PREVIOUS SPACECRAFT HAVE BEEN ASSEMBLED, TESTED AND THOROUGHLY CHECKED OUT ON THE GROUND BEFORE LAUNCH. BECAUSE OF THE SIZE, WEIGHT AND CONFIGURATION OF THE STATION, THOSE PROCESSES WILL HAVE TO BE UNDERTAKEN IN ORBIT, WHERE RELATIVELY MINOR ADJUSTMENTS AND REPAIRS ARE SERIOUS CHALLENGES TO WEIGHTLESS ASTRONAUTS IN BULKY SPACE SUITS. SPECIAL HARDWARE, TOOLS AND PROCEDURES WILL BE REQUIRED TO DO THE JOB.

ONCE ASSEMBLED, MANNED AND OPERATIONAL, MAINTENANCE WILL BE A FURTHER CHALLENGE. HOW WILL WE KEEP THIS CRUCIAL NATIONAL RESOURCE IN A-1 SHAPE? UP TO NOW, MOST SPACE SYSTEMS HAVE NOT BEEN DESIGNED FOR ON-ORBIT REPAIRS AND MAINTENANCE. BUT THE STATION WILL BE IN SERVICE FOR AT LEAST THIRTY YEARS, AN ENTIRE HUMAN GENERATION. ACTIVE COMPONENTS, NO MATTER HOW RUGGEDLY DESIGNED AND BUILT, WILL INEVITABLY WEAR OUT OR FAIL. THE CHALLENGE IS TO ASSURE EASY ACCESS FOR MAINTENANCE, AND SIMPLE AND QUICK REPLACEMENT OR REPAIR.

BEYOND THE HARDWARE, MAINTENANCE IN ORBIT WILL REQUIRE A CONFIGURATION CONTROL PROGRAM MORE COMPREHENSIVE AND DETAILED THAN ANY NOW EXISTING. RECORDS ON PARTS QUALIFICATION TESTS, INTERCHANGEABILITY, MANUFACTURING SPECIFICATIONS, AND MAINTENANCE AND INTERFACE, DATA WILL NEED TO BE KEPT CURRENT FOR DECADES. STANDARDIZATION OF ENGINEERING DESIGN PRACTICES AND PROCEDURES WILL BE ESSENTIAL, EVEN WITH THE MOST SKILLED ENGINEERS AND SPACE MECHANICS ON THE JOB.

IN ORDER TO COMMUNICATE WITH EARTH AND OTHER SPACE FACILITIES, THE STATION WILL HAVE TO MAINTAIN PRECISE POSITIONAL ATTITUDES IN ORBIT. AND THE THOUSANDS OF SQUARE FEET OF THE STATION'S SURFACE, PARTICULARLY THE HUGE SOLAR ARRAYS, WILL CONTINUOUSLY WORK TO DECAY THE ORBITAL ALTITUDE. IN ORDER TO COUNTER THAT EFFECT AND MAINTAIN PROPER ORIENTATION, WE MUST PROVIDE THRUST FROM ON-BOARD PROPULSION SYSTEMS WITH MINIMUM ADDED WEIGHT, A MINIMUM OF DANGEROUSLY VOLATILE FUELS, AND MINIMUM ADDED COMPLEXITY.

THE SYSTEM WE HAVE DESIGNED TO MAINTAIN ATTITUDE WILL USE ELECTROLYSIS TO BREAKDOWN WASTE WATER INTO GASEOUS HYDROGEN AND GASEOUS OXYGEN WHICH WILL FUEL THE PROPULSION THRUSTERS, AND THEN RECOMBINE TO FORM WATGER VAPOR AS A BYPRODUCT.

THE PROPULSION SYSTEM TO BE USED TO MAINTAIN OR CHANGE ALTITUDE WILL USE THE STATION'S WASTE GASES AS PROPELLANTS.

**ANOTHER ENGINEERING CHALLENGE** WILL BE THE REQUIREMENT TO CONDUCT EXPERIMENTS IN THE TELESCIENCE MODE TO PERMIT INVESTIGATORS IN WIDELY DISPERSED LOCATIONS ON THE GROUND AND IN SPACE TO INTERACT. THIS WILL REQUIRE THE DESIGN OF A DATA NETWORK ABLE TO COLLECT, DOWNLINK AND DISTRIBUTE WORLD-WIDE THE ENORMOUS AMOUNTS OF SCIENTIFIC DATA THAT WILL BE PRODUCED ABOARD THE STATION.

AND THESE ARE ONLY SOME OF THE CHALLENGES TO BE FACED OVER THE NEXT FEW YEARS AS WE BUILD THE INFRASTRUCTURE FOR PERMANENT HUMAN OCCUPANCY OF SPACE.

BUT AMERICANS HAVE HISTORICALLY THRIVED AND FLOURISHED ON CHALLENGES MET AND OVERCOME. THE CHALLENGES INHERENT IN THE EXPLORATION OF SPACE AND THE ACTUALIZATION OF THE FREEDOM SPACE STATION, ALTHOUGH AS DEMANDING AS ANY IN OUR HISTORY, OFFER PROPORTIONATE REWARDS THAT ADD UP TO IMMEASURABLE BENEFITS TO OUR COUNTRY AND ALL THE PEOPLE OF OUR BEAUTIFUL BLUE PLANET.

THANK YOU. I INVITE YOUR QUESTIONS.